IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Tinghao F. Wang
Serial No.:	10/071,809
Filing Date:	February 7, 2002
Title:	METHOD FOR SELECTIVELY ETCHING SILICON AND/OR METAL SILICIDE
Examiner:	Duy Vu Nguyen Deo
Group Art Unit:	1765

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPLICANT'S REPLY BRIEF TO THE SUPPLEMENTAL EXAMINER'S ANSWER, IN SUPPORT OF THE APPEAL TO THE BOARD OF PATENT APPEALS AND INTERFERENCES, UNDER 37 C.F.R. 41.41

Applicant requests that the appeal be maintained, and a Reply Brief as set forth in 37 C.F.R. 41.41 is set forth below.

TABLE OF CONTENTS

I. SUMMARY OF CLAIMED SUBJECT MATTER

WSi_x (metal silicide)/poly-Si (polysilicon) stack structures are used for gate electrodes. (Application: Page 2, Lines 11-13). Dry etching techniques are desirable that will etch a vertical profile through these stack structures without etching through the polysilicon or the gate dielectric that lies beneath the stack. (Application: Page 2, Lines 15-17). Fluorine-based etching gases have high metal silicide etching rates, but undesirably etch polysilicon and the underlying oxide that forms the gate dielectric. (Application: Page 2, Lines 19-21). Chlorine-based etching gases provide higher selectivity than fluorine-based gases, thus preserving the polysilicon and the oxide layers, but are slower. (Application: Page 2, Lines 22-24).

The present invention makes use of the discovery that O_2 concentrations of at least 25% by volume in the chlorine-based etching gas, not only provide high metal silicide etch rates, but selectively etch metal silicide over polysilicon at a ratio of at least 30:1. (Application: Page 6, Lines 11-15).

II. GROUND OF REJECTION TO BE REVIEWED ON APPEAL

The issue to be decided on this appeal is whether the specification does not reasonably provide enablement for claims 1, 3-12, 14-15, 21-23, 25, and 27 under 35 U.S.C. § 112, first paragraph.

III. ARGUMENT

Contrary to the Examiner's statement in the Supplemental Examiner's Answer, Nojiri et al. (Nojiri)(*J. Vac. Sci. Technol.* B14(3), May/June 1996, p. 1791-1795) does not contain any examples of etching a metal silicide layer employing an oxygen concentration above 25%. Nojiri extrapolate the etch rate of a tungsten silicide (WSi_x) layer during etching employing an oxygen concentration above 20%, based on the etch rates of a tungsten silicide layer during etching employing oxygen concentrations of 20% and below, and the etch rates of polysilicon during etching employing oxygen concentrations of 0% to 25%. Furthermore, the present application provides all the details needed to make and use the claimed invention, including a drawing and text, and contains a detailed example of the claimed method as actually carried out.

Nojiri describes a high rate and highly selective anisotropic etching for WSi_x/poly-Si. Described is that tungsten polycide (WSi_x/polysilicon) structures are widely used as a gate material, and therefore prefect anisotropic etching of both WSi_x and polysilicon is need to minimize the critical dimension loss. Furthermore, high selectivity to the underlying gate SiO_2 is required. Therefore,

Nojiri is interested in anisotropic etching of tungsten polycide structures (a combination of a WSi_x layer on a polysilicon layer), which is highly selective to SiO_2. (Nojiri at p.1791, left column, first paragraph.)

Nojiri present etch rate data for the etching of WSi_x employing 0%, 10% and 20% oxygen, and etch rate data for the etching of polysilicon employing 0% to 25% oxygen. Figure 2 of Nojiri (p.1792, left column) includes data points for the etch rate of WSi_x during etching employing 0%, 10% and 20% oxygen (black circles), and data points for the etch rate of polysilicon during etching employing 0%, 10%, 20%, about 23% and 25% oxygen (white circles). Lines which interpolate the etch rates for both WSi_x and polysilicon during etching employing 0% to 25% oxygen have been graphed with the data points: the line which interpolates the etch rate for WSi_x during etching employing more than 20% oxygen indicates an etch rate which goes to zero as the amount of oxygen employed approaches 25%, even though no data points for etching employing more than 20% oxygen appear on the graph.

The text of Nojiri describing Figure 2 (p.1792, left column) does not comment on the etch rate for WSi_x during etching employing more than 20% oxygen. The text of Nojiri describing Figure 2 states that the etching of polysilicon stops when the oxygen concentration exceeds 20%, and that the etch rate of WSi_x increases with oxygen concentration up to 10% and has the same value as that of polysilicon:

> Figure 2 shows the O_2 concentration dependence of the etch rate and the selectivity, at a rf power of 150 W. The etch rate of poly-Si is almost constant in the O_2 concentration range of 0%-20%, and the etching suddenly stops when the O_2 concentration exceeds 25%. Above this concentration, a film was deposited on the wafer surface. The etch rate of WSi_x increases with increasing the O_2 concentration up to 10%, and has the same value as that of poly-Si.

The data presented in Nojiri is consistent with the process claimed in the present application; only the <u>projection</u> in Nojiri of the etch rate of WSi_x during etching employing more than 20% oxygen is inconsistent with the process claimed in the present application. Nojiri never provides experimental values for the etch rate of WSi_x during etching employing more than 20% oxygen, and never indicates in the text anything about this etch rate. The only information about the etch rate of WSi_x during etching employing more than 20% oxygen is the projection of the etch rate in Figure 2. Therefore, none of the experimental results of Nojiri are inconsistent with the process claimed in the present application.

The claimed process includes a metal silicide etch that is selective to poly-silicon, while Nojiri describe an etch of tungsten polycide structures (a combination of a WSi_x layer on a polysilicon layer), which is selective to SiO_2. The present application provides all the details necessary to carry out the claimed process: gas flow rates, suitable plasma reactors, gas pressures, source power, bias power, and time of etching, are all provided on page 7 of the

application. Accordingly, the specification of the present application does provide enablement for the claimed process.

A specification disclosure which contains a teaching of the manner and process of making and using an invention in terms which correspond in scope to those used in describing and defining the subject matter sought to be patented must be taken as being in compliance with the enablement requirement of 35 U.S.C. § 112, first paragraph, unless there is a reason to doubt the objective truth of the statements contained therein which must be relied on for enabling support: "it is incumbent upon the Patent Office, whenever a rejection on this basis is made, to explain *why* it doubts the truth or accuracy of any statement in a supporting disclosure and to back up assertions of its own with acceptable evidence or reasoning which is inconsistent with the contested statement." M.P.E.P. § 2164.04, citing *In re Marzocchi*, 439 F.2d 220, 224, 169 USPQ 367, 370 (CCPA 1971). Since Nojiri does not contain any experimental results inconsistent with the claimed process, there is no reason to doubt the truth or accuracy of any statement in the supporting disclosure, and there is no evidence inconsistent with the supporting disclosure. Applicant submits that the description in the present application of how to make and use the invention is sufficient to meet the enablement requirement of 35 U.S.C. § 112, first paragraph.

IV.CONCLUSION

For the foregoing reasons, the claim rejection applied by the Examiner under 35 U.S.C. § 112, first paragraph is unsustainable. Applicants respectfully request reversal of the Examiner's rejections.

Respectfully submitted,

Dated:

Paul E. Rauch, Ph.D.
Registration No. 38,591

Evan Law Group LLC
566 West Adams St., Suite 350
Chicago, IL 60661
(312) 876-1400

V. CLAIMS APPENDIX

1. (Previously Presented) A method comprising, etching a metal silicide layer during fabrication of an integrated circuit in a $Cl_2/0_2$ environment having an 0_2 concentration of greater than or equal to 25% by volume,

wherein the Cl_2/O_2, environment is provided at a pressure of approximately 2-40 mili-Torr, and wherein the etching is a metal silicide etch that is selective to poly-silicon with a ratio of etch rates of at least 30.

2. (Cancelled)

3. (Original) The method of claim 2 wherein the pressure is approximately 3 mili-Torr.

4. (Original) The method of claim 1 wherein the $Cl_2/0_2$ environment is provided in a reactor with a source power of approximately 200 - 2000 Watts.

5. (Original) The method of claim 4 wherein the source power is approximately 400 Watts.

6. (Original) The method of claim 1 wherein the Cl_2/O_2 environment is provided in a reactor having a bias power of approximately 35 to 400 Watts.

7. (Original) The method of claim 6 wherein the reactor has a bias power of approximately 50 Watts.

8. (Original) The method of claim 1 wherein the metal silicide layer is a tungsten silicide layer.

9. (Original) The method of claim 1 wherein the $Cl_2/0_2$ environment comprises approximately 45 sccm Cl_2 and 30 sccm 0_2.

10. (Original) The method of claim 9 wherein the Cl_2/O_2 environment is provided for a time period sufficient to completely etch the metal silicide layer.

11. (Original) The method of claim 9 wherein the time period is approximately 30 seconds.

12. (Previously Presented) A method comprising etching a metal silicide layer during fabrication of an integrated circuit in an environment having a concentration of 0_2 greater than 25% by volume so as to selectively etch the metal silicide layer with respect to an underlying poly-silicon layer with a ratio of etch rates of at least 30,

wherein the etching is carried out at a pressure of 2-40 mili-Torr.

13. (Cancelled)

14. (Original) The method of claim 12 wherein the environment comprises approximately 45 sccm Cl_2 and 30 sccm 0_2.

15. (Original) The method of claim 12 wherein the metal silicide is chosen from the group consisting of tungsten silicide, chromium silicide and titanium silicide.

16-20. (Cancelled)

21. (Previously Presented) A method of etching a metal silicide,

comprising etching of the metal silicide with a plasma,

wherein the plasma is prepared from a gas mixture comprising: chlorine, and greater than 25% by volume oxygen,

the etchinq is carried out at a pressure of 2-40 mili-Torr, and

the etching is a metal silicide etch that is selective to poly-silicon with a ratio of etch rates of at least 30.

22. (Previously Presented) The method of claim 21, further comprising, prior to said etching, a breakthrough etch.

23. (Previously Presented) The method of claim 22, wherein said breakthrough etch comprises etching with a plasma prepared from a gas comprising CF_4.

24. (Cancelled)

25. (Previously Presented) The method of claim 1, further comprising, prior to said etching, a breakthrough etch.

26. (Cancelled)

27. (Previously Presented) The method of claim 21, wherein said gas mixture comprises: chlorine and from 25% to 30% by volume oxygen.